WRP Technical Note HY-DE-4.1
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Methods to Determine the Hydrology of Potential Wetland Sites

PURPOSE: This technical note describes a number of field-tested methodologies for evaluating the hydrology of potential wetland sites.

BACKGROUND: The U.S. Army Corps of Engineers "Wetlands Delineation Manual" (Environmental Laboratory 1987) requires that the hydrology, soils, and vegetation of a site be assessed independently for wetland determinations. The presence of hydric soils and hydrophytic vegetation is determined by direct observation. However, the hydrology generally is not determined by field observations alone, since this evaluation involves an extended period of continuous monitoring of inundation or saturation during the growing season. Wetland determinations in routine cases are based in part on ***indicators*** of hydrology that are observable during a brief site visit. Direct hydrologic measurements are possible only in difficult or controversial cases, because field personnel seldom have the time and resources to monitor sites for extended periods of time. Therefore, for routine wetland determinations, the frequency and duration of inundation or saturation are most effectively determined using analytical techniques. Until recently, no analytical methods to determine wetland hydrology had been developed, compiled, and described.

To meet this need, the U.S. Army Corps of Engineers and the Natural Resources Conservation Service (NRCS), in conjunction with other Federal agencies, developed a handbook, "Hydrology Tools for Wetland Determination" (Woodward 1997), which describes a series of analytic approaches to determining the long-term hydrology of a site. The Handbook has undergone extensive peer review to ensure that it serves the needs of Federal and state agencies involved in wetland determination, restoration, and mitigation monitoring. In addition, the tools presented in the Handbook have been field tested to evaluate their strengths and limitations in assessing the hydrology of potential wetland sites (Woodward and Warne 1997).

This technical note summarizes the hydrology tools described in detail in the Handbook (Woodward 1997). An interagency course ("Hydrology Tools for Wetland Determination") is available to Corps personnel, and the course materials are presented in Woodward and others (1996). Further information can be obtained from the individuals listed at the conclusion of this technical note.

DESCRIPTION OF HYDROLOGY TOOLS:

- Stream gauge analysis. In many cases, the timing, frequency, and duration of inundation of riverine wetlands can be evaluated using stream gauge data. This method identifies the critical consecutive-day period (i.e., 5 to 12 percent of the growing season) for which stage is the highest during the growing season, and compares these stage levels with the stage level that would inundate the site. The critical consecutive-day period of highest stage is determined for each of at least 10 years and compared with the minimum stage necessary to inundate the potential wetland site. If the site is continuously inundated for the length of time specified by regulation for at least 5 out of 10 years (that is, at least 50 percent of the years), then stream gauge analysis indicates that the site has wetland hydrology.

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If the site has significant topographic relief, the task would be to identify the elevation below which hydrology criteria are met. This may require a detailed site survey. Even though stream gauge analysis alone may not indicate continuous inundation of the area being evaluated for the critical number of days during the growing season for the majority of years, this analysis provides essential information regarding the water budget of the evaluation site.

For example, if analysis reveals that the site is frequently inundated during the growing season, and the site is located in a depressional area underlain by relatively impervious soils, the site might meet wetland hydrology conditions by a combination of inundation and soil saturation. On the other hand, a site that is not commonly inundated for the critical number of consecutive days during the growing season, is not in a depressional portion of the floodplain, and has a substrate composed of pervious material that typically shows scour and flow structures probably does not have wetland hydrology.

This method requires that a stream gauge be located relatively close (300 m) to the area to be evaluated; otherwise, stream profiles must be generated. The stream gauge data must be continuous during the growing season for a minimum of 10 years. If only published streamflow data are available, a rating curve will be necessary to convert streamflows to stages.

More information on stream gauging data is available from the U.S. Geological Survey (USGS) Earth Science Information Center at (800) 872-6277, State USGS Water Resource Service offices, or on the Internet at *http://www.usgs.gov/network/science/earth/usgs.html*. Other data sources are described in Woodward (1997).

- Remote sensing. This procedure correlates precipitation or runoff data with what is seen on aerial photography, commonly U.S. Department of Agriculture (USDA) crop history slides. Using this tool, the analyst determines the number of times that wet signatures are visible at a site on a series of aerial photographs taken over a number of years. Wet signatures include standing water, soil saturation, and stressed crops.

  Photographs may be normal color or color infrared. The USDA Consolidated Farm Service Agency Aerial Photography Lab, (801) 975-3503, can provide aerial photographs over a period of years for cropped areas in many parts of the country. The USGS Earth Resources Observation System data center, (605) 594-6151, is also a major source of aerial photography. Other data sources are described in Woodward (1997).

  Essential to this procedure is to determine whether each photograph was taken during a normal, wetter then normal, or drier than normal growing season, and whether the 3 months prior to the time each photograph was taken were wet, normal, or dry. Because antecedent moisture conditions are so important, it is essential that the date of each aerial photograph be known. WETS tables, developed by the NRCS, provide climate data for the last 30 years at National Weather Service weather stations throughout the country in a convenient format for hydrologic analysis of wetlands. As shown in the sample WETS table (Table 1), other relevant information is provided, such as timing and duration of growing season.

  To use the WETS tables, one compares the actual precipitation for a particular month or year with the “normal” range shown in the table. The Internet address to obtain WETS tables is *http://www.wcc.nrcs.usda.gov/water/w_clim.html*.

Table 1
WETS Table Example[1]

WETS Station: DE SMET, SD2302
Latitude: 4423 Longitude: 09733 Elevation: 01750
State FIPS/County (FIPS): 46077 County Name: Kingsburg
Start yr. - 1961 End yr. - 1990
Temperature: 30 years available out of 30 requested in this analysis
Precipitation: 30 years available out of 30 requested in this analysis

	Temperature (Degrees F)			Precipitation (in.)				
					30 Percent Chance Will Have			
Month	Average Daily Maximum	Average Daily Minimum	Average	Average	Less Than	More Than	Average No. Days with 0.1 or More	Average Total Snowfall
January	23.0	2.4	12.7	0.60	0.31	0.78	2	6.6
February	29.3	9.0	19.2	0.68	0.41	0.89	2	7.0
March	41.3	21.1	31.2	1.60	0.87	1.95	3	8.9
April	58.7	34.2	46.5	2.26	1.28	2.75	4	1.6
May	71.1	45.8	58.5	3.05	1.82	3.69	5	0.0
June	80.3	55.8	68.0	4.02	2.59	4.84	6	0.0
July	86.2	61.1	73.7	3.25	1.96	3.93	4	0.0
August	83.9	58.6	71.3	2.44	1.51	2.95	4	0.0
September	73.7	48.7	61.2	2.14	1.03	2.61	4	0.0
October	61.0	36.8	48.9	1.78	0.83	2.25	3	0.8
November	41.7	22.5	32.1	0.92	0.34	1.11	2	5.4
December	26.7	8.1	17.4	0.58	0.32	0.73	1	6.0
Annual	--	--	--	--	19.83	26.03	--	--
Average	56.4	33.7	45.1	--	--	--	--	--
Total	--	--	--	23.30	--	--	40	36.3

Growing Season Dates
Requested years of data: 30 Available years of data: 30
Years with missing data 24 deg = 0, 28 deg = 0, 32 deg = 0
Years with no occurrence 24 deg = 0, 28 deg = 0, 32 deg = 0
Data years used 24 deg = 30, 28 deg = 30, 32 deg = 30

	Temperature		
Probability	24 F or Higher	28 F or Higher	32 F or Higher
	Beginning and Ending Dates Growing Season Length		
50 percent*	4/16 to 10/22 189 days	4/27 to 10/9 165 days	5/4 to 9/29 148 days
70 percent*	4/12 to 10/27 198 days	4/22 to 10/13 174 days	5/1 to 10/3 155 days

*** Percent chance of the growing season occurring between the beginning and ending dates.**

[1] Full WETS tables include a record of monthly total precipitation for each year for the period 1961 to 1995.

Although NRCS standards for evaluating the hydrology of potential wetland sites using aerial photography vary from State to State, they typically require a minimum of five growing seasons of photography with normal antecedent meteorological conditions. If 5 years of photography taken during normal rainfall seasons is not available, it is common practice to include at least one photograph from a wetter than normal season and one from a slightly drier than normal season.

- Monitoring wells. Areas that are not ponded or flooded for more than a few hours or days, but where the soil remains continuously saturated within the root zone for a significant portion of the growing season, present a special challenge to evaluating the hydrology of potential wetland sites. Observation wells are the most reliable instruments for evaluating the timing, duration, and frequency of saturation at these sites.

  Currently, many groundwater monitoring wells used for wetland regulatory compliance are not properly installed or constructed. Number, locations, and depths of wells are commonly not adequate to determine the long-term shallow groundwater hydrology of a site. Moreover, there continues to be considerable confusion about the design and use of monitoring wells versus piezometers among wetland scientists. Another common problem associated with shallow groundwater analysis is that water-table readings are not frequent enough to determine whether soils remain continuously saturated in the root zone for the critical length of time during the growing season.

  To obtain statistically valid assessment of the long-term hydrology of sites, at least 10 years of water- table data are generally considered necessary. However, few sites have shallow groundwater monitoring well records of this length. Using WETS tables from the nearest climatic station, along with daily precipitation records for the growing season for the time monitoring wells have been installed, may reduce the period of record necessary to evaluate the long-term hydrology of a potential wetland site. Procedures for determining optimal well locations and depths at a site, installing wells, determining the timing and frequency of water-level readings in wells, and reporting results are being further developed at the U.S. Army Engineer Waterways Experiment Station.

- Runoff volumes. Estimates of runoff volume on a daily, monthly, seasonal, and annual basis have been used to determine the frequency and duration of inundation in potholes and floodplain depressions, the antecedent soil moisture conditions for wetlands in semi-arid or arid conditions, and the relationship of drainage and playa surface area.

  Runoff volumes can be determined using the following three procedures:

  — Manual techniques using precipitation and runoff curve numbers.
  — Computer models.
  — Daily runoff volumes from recording stream gauges.

  The curve number procedure is a simple method that provides the investigator with a general understanding of the response of the drainage area to precipitation events and, thereby, provides a clearer picture of the hydrology of potential wetland sites. Data requirements for manual determination of daily runoff using the curve number method include the following: daily precipitation data for a minimum of 30 years from a representative climate station within the area of interest; soils data for the drainage area; land use, cover type, and hydrologic conditions for the drainage area; and planting and harvesting dates for the typical crops in the drainage area.

Data requirements for computer simulation models are generally similar, but vary with the specific program. Standard input data include those listed above, plus watershed characteristics such as drainage area, stream length, and land slope. Most computer models are time consuming to initiate and require trained personnel. However, they can produce accurate runoff simulations that may be required for controversial cases.

- Scope and effect equations. Several equations that were originally developed to evaluate the effect of artificial drainage systems on agricultural soils can help determine the effect of water management measures such as ditches, tiles, and diversions on potential wetland sites. Standard NRCS drainage equations that are currently being used to evaluate the hydrology of sites for wetland regulatory compliance include the ellipse, Hooghoudt, van Schilfgaarde, and Kirkham equations.

  The ellipse equation has long been used to design agricultural drainage and water supply systems in the United States. It is a steady-state equation in that it assumes the system steadily removes rain that falls at a constant rate. The Hooghoudt and van Schilfgaarde are more complex versions of the ellipse equations and accommodate such factors as complex soil stratigraphy and nonsteady-state rainfall. The Kirkham equation takes into account ponded water at a site.

- DRAINMOD. This computer model was originally developed to investigate drainage and subirrigation systems and their effects on water use and crop response (Workman and others 1994). DRAINMOD has subsequently been modified to determine the hydrology of potential wetland sites by incorporating a counting procedure that keeps track of the number of days an area is wet and the number of occurrences of prolonged saturated soil conditions during the growing season.

  Successful use of DRAINMOD requires trained personnel to run the program and the following data:

— Hourly precipitation.
— Daily maximum and minimum temperatures.
— Drainage parameters, such as depth of drains, drain spacing, effective radius of the drains, distance from drain to restrictive layer, drainage coefficient, storage in local depressions, and maximum surface storage.
— Soil parameters, such as lateral saturated hydraulic conductivity, soil water characteristics by soil layers, volume of water free to drain by soil layers, upward flux, Green and Ampt parameters, and water content at permanent wilting point.
— Growing season information, such as threshold water-table depth, required duration of high water, and beginning and ending dates for the growing season.

DRAINMOD has been proven useful in several litigation cases and in other instances where the hydrology of a site was disputed.

APPLICATION: Systematic field testing of these hydrology tools has shown that they generally agree with hydrologic assessments made using proxy hydrologic indicators and long-term observations of the hydrology of sites (Woodward and Warne 1997). The tools have proved successful in a variety of landscape settings in different regions of the United States. When used properly, these procedures can provide valuable information regarding the long-term hydrology of potential wetland sites. These tools are most effective if used in conjunction with the WETS tables and if two or more tools are applied at a given site.

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POINT OF CONTACT FOR ADDITIONAL INFORMATION: Dr. Andrew G. Warne, U.S. Army Engineer Waterways Experiment Station, ATTN: CEWES-GG-Y, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, phone: (601) 634-2186, e-mail: *warnea@ex1.wes.army.mil*.

Mr. Donald E. Woodward, Natural Resources Conservation Service, Conservation Engineering Division, P.O. Box 2890, Washington, DC 20013-2890, phone: (202) 720-0772, e-mail: *don/woodward@usda.gov*.